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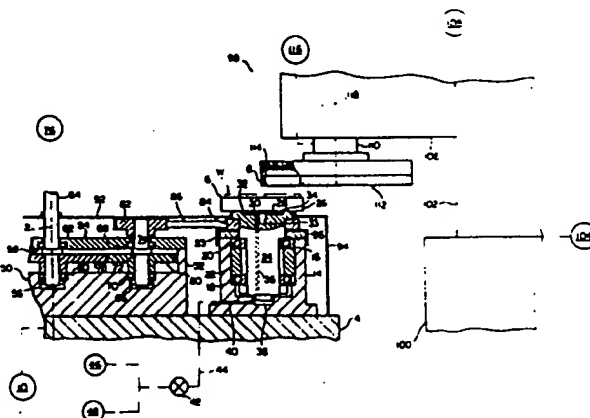
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**Surface grinding apparatus.**

A surface grinding apparatus for grinding the surface of a workpiece (W) such as a semiconductor wafer. The surface grinding apparatus comprises a support stand (4), at least one workpiece holding chuck table (6) rotatably mounted on the support stand (4), a rotatably mounted grinding wheel (8) for grinding the surface of the workpiece (W) held on the chuck table (6), chuck table rotating means (76) for rotating the chuck table (6) and wheel rotating means (116) for rotating the grinding wheel (8). When grinding the surface of the workpiece (W) held on the chuck table (6) with the grinding wheel (8), the grinding wheel (8) is rotated and the chuck table (6) is also rotated to rotate the workpiece (W) held on the chuck table (6).



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SURFACE GRINDING APPARATUSFIELD OF THE INVENTION

This invention relates to a surface grinding apparatus, and more specifically, to a surface grinding apparatus particularly adapted for grinding the surface of a semiconductor wafer.

DESCRIPTION OF THE PRIOR ART

As is well known to those skilled in the art, the manufacturing of semiconductor devices requires the grinding of the surface of a nearly disc-shaped semiconductor wafer to make the thickness of the semiconductor wafer as required. In general, a surface grinding apparatus as disclosed in the specification of Japanese Laid-Open Patent Publication No. Sho 56-152562 (or U.S. Patent No. 4,481,738 or European Patent Publication No. 0 039 209) is conveniently used as a surface grinding apparatus for grinding the surface of a semiconductor wafer. This surface grinding apparatus comprises a rotatably mounted support table, a plurality of semiconductor wafer holding chuck tables fixed to the support table, a plurality of grinding wheels rotatably mounted at intervals in the rotating direction of the support table, table rotating means for rotating the support table and wheel rotating means for rotating the grinding wheels.

In the aforesaid surface grinding apparatus, a semiconductor wafer to be ground on its surface is held on the chuck table. Each of the plurality of grinding wheels is rotated at a relatively high speed and the support table is also rotated at a relatively low speed. Consequently, the semiconductor wafer held on the chuck table fixed to the support table

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is permitted passage beneath the plurality of rotating grinding wheels successively, whereby the surface of the semiconductor wafer is ground with the rotating grinding wheels.

5           As is understood from the description in the specification of Japanese Laid-Open Patent Publication No. Sho 56-152562 (or U.S. Patent No. 4,481,738 or European Patent Publication No. O 039 209), the aforesaid surface grinding apparatus has various  
10 advantages over other types of conventional surface grinding apparatuses. It is not, however, fully satisfactory and it has problems to be solved that (a) a grinding wheel of an annular shape as a whole is used in the aforesaid surface grinding apparatus and  
15 the outer diameter of the grinding wheel needs to be sufficiently larger than the outer diameter of a semiconductor wafer to be ground in order to uniformly grind the whole surface of the semiconductor wafer with such a grinding wheel. Therefore, when a  
20 semiconductor wafer is made large, the grinding wheel needs to be correspondingly made large. It is not always easy, however, to produce a grinding wheel of a large diameter by bonding super abrasive grains such as natural or synthetic diamond abrasive grains  
25 by a suitable method in view of various aspects of the wheel production process; and (b) the relative movement of a semiconductor wafer to the rotating grinding wheel in the grinding is only the sending movement of the semiconductor wafer accompanied by the  
30 rotation of the support table at the relatively low speed and the grinding trails by the grinding wheel on the semiconductor wafer are simple arc-shaped ones defined by the movement of the outer peripheral edge of the rotating grinding wheel. Therefore,

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the grinding resistance is relatively large and it relatively largely varies according to the aforesaid sending movement of the semiconductor wafer. Then, it is difficult to carry out a sufficiently uniform grinding throughout the whole surface of the semiconductor wafer and the grinding accuracy is limited.

#### SUMMARY OF THE INVENTION

It is a primary object of this invention to provide an improved surface grinding apparatus, a surface grinding apparatus particularly adapted for grinding the surface of a semiconductor wafer, in which a grinding wheel is not necessarily made large in diameter even when a semiconductor wafer is made large in diameter and it is possible to carry out a sufficiently uniform grinding throughout the whole surface of a semiconductor wafer and obtain a required grinding accuracy.

It has now been found as a result of extensive investigations and experiments of the present inventor that the aforesaid object can be attained by rotatably mounting a workpiece holding chuck table on a support stand, by providing chuck table rotating means for rotating this workpiece holding chuck table, and when grinding the surface of a workpiece held on the chuck table with a grinding wheel, by rotating the grinding wheel and also rotating the chuck table to rotate the workpiece held on the chuck table although a workpiece holding chuck table has been fixed to a support stand such as a support table in a conventional surface grinding apparatus.

According to this invention, there is provided a surface grinding apparatus comprising a support

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stand, at least one workpiece holding chuck table rotatably mounted on the support stand, a rotatably mounted grinding wheel for grinding the surface of a workpiece held on the chuck table, chuck table rotating  
5 means for rotating the chuck table and wheel rotating means for rotating the grinding wheel, wherein when grinding the surface of the workpiece held on the chuck table with the grinding wheel, the grinding wheel is rotated and the chuck table is also rotated to  
10 rotate the workpiece held on the chuck table.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a simplified top plan view showing the major constituents of one embodiment of the surface  
15 grinding apparatus constructed in accordance with this invention;

Figure 2 is a sectional view showing a part of the surface grinding apparatus of Figure 1;

Figure 3 and Figure 4 are simplified partial  
20 top plan views for explaining modifications of the surface grinding manner by means of the surface grinding apparatus of Figure 1; and

Figure 5 is a sectional view, similar to Figure 2, showing a modified embodiment of the chuck  
25 table rotating means.

#### DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Preferred embodiments of the surface grinding apparatus constructed in accordance with this  
30 invention will be described below in detail with reference to the accompanying drawings.

Figure 1 simply illustrates the major constituents of one embodiment of the surface grinding apparatus constructed in accordance with this

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invention. The illustrated surface grinding apparatus is provided with a disc-shaped support table 4 of a relatively large diameter mounted for rotation about the central axis 2 extending substantially perpendicularly (vertically to the paper in Figure 1). A plurality of, four in the illustrated embodiment, disc-shaped workpiece holding chuck tables 6 are rotatably mounted on the support table 4 which constitutes a support stand at circumferentially spaced positions. Conveniently, the plurality of chuck tables 6 are respectively arranged at a plurality of positions whose radial distances from the central axis 2 are the same one another and which are at equal intervals in the circumferential direction of the support table 4 (i.e. at equal angular intervals).

Work stations A, B, C and D are respectively defined to the aforesaid plurality of, four in the illustrated embodiment, positions spaced in the circumferential direction of the support table 4. Conveniently, these work stations A, B, C and D are positioned at equal intervals in the circumferential direction of the support table 4 (i.e. at equal angular intervals) and the mutual angular interval between the work stations A, B, C and D is consistent with the mutual angular interval between the plurality of chuck tables 6. The work station A is a workpiece unloading and loading station. In the workpiece unloading and loading station A, a workpiece ground on its surface is taken out from the chuck table 6 by a suitable unloading means (not shown) and a new workpiece to be ground on its surface is placed on the chuck table 6 by a suitable loading means (not shown). The work stations B, C and D are a rough grinding station, an intermediate grinding station and

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a finishing grinding station respectively. A grinding wheel assembly having a grinding wheel 8 is disposed to each of these grinding stations B, C and D. The surface of a workpiece held on the chuck table 6 is  
5 subjected to a rough grinding in the rough grinding station B, an intermediate grinding in the intermediate grinding station C and a finishing grinding in the finishing grinding station D to be described in more detail hereinafter.

10 With reference to Figure 2 as well as Figure 1, the structure of the support table 4 and the chuck tables 6 mounted on the support table 4 is described in detail. In the illustrated surface grinding apparatus, a static main support shaft (not shown) extending  
15 substantially perpendicularly along the central axis 2 of the support table 4 is disposed and the support table 4 is rotatably mounted on the upper end portion of this main support shaft. A table rotating means 10 such as an electric motor is drivingly connected to the  
20 support table 4 through a suitable transmitting element (not shown) and the support table 4 is intermittently or continuously rotated in the direction shown by an arrow 12 in Figure 1 by the table rotating means 10 to be described in more detail hereinafter. Four  
25 chuck table support blocks 14 (only one of them is shown in Figure 2) are fixed to the peripheral edge portion of the substantially horizontal upper surface of the support table 4 at circumferentially equally spaced positions and the chuck table 6 is rotatably  
30 mounted on each of these chuck table support blocks 14. More specifically, a circular opening 16 open upwardly is formed in the chuck table support block 14 which may be nearly cylindrical, and bearing members 18 and 20 are disposed in this opening 16. The under

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surface of the bearing member 18 is caused to abut against an annular shoulder portion formed in the opening 16, an annular spacer member 22 is disposed between the bearing members 18 and 20, the internal  
5 peripheral edge portion of the under surface of an annular support plate 23 fixed to the upper surface of the chuck table support block 14 is caused to abut against the upper surface of the bearing member 20, and thus the bearing members 18 and 20 are held at  
10 required positions. The under portion of a rotating shaft 24 is inserted in the bearing members 18 and 20, and thus the rotating shaft 24 is rotatably mounted on the chuck table support block 14. The chuck table 6 is fixed to the upper end of the rotating shaft 24  
15 protruding upwardly beyond the chuck table support block 14. The illustrated chuck table 6 has a disc-shaped main portion 26, a circular protrusion 28 formed on the under surface of the main portion 26 and a connecting screw portion 30 extending downwardly  
20 from the center of the circular protrusion 28. On the other hand, a circular depression 32 for receiving the circular protrusion 28 of the chuck table 6 and a screw hole 33 bored in the center of the circular depression 32 are formed in the upper surface of the  
25 rotating shaft 24. The connecting screw portion 30 of the chuck table 6 is screwed into the screw hole 33 of the rotating shaft 24 and thus the chuck table 6 is fixed to the upper end of the rotating shaft 24. In the state that the chuck table 6 is fixed to the  
30 rotating shaft 24 as required, there is a small interval between the under surface of the circular protrusion 28 of the chuck table 6 and the bottom surface of the circular depression 32 of the rotating shaft 24, and a closed space 34 is defined between



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the both. In the rotating shaft 24 is formed a passage 36 extending axially from its upper end open to the bottom surface of the circular depression 32 to its lower end open to the under surface of the rotating shaft 24. A hollow manifold 38 is fixed to the central portion of the bottom surface of the opening 16 formed in the chuck table support block 14 and the lower end of the passage 36 is adapted for communication with this manifold 38. In the lower end portion of the chuck table support block 14 is formed a passage 40 extending radially from its internal end adapted for communication with the manifold 38 to its external end open to the outer peripheral surface of the chuck table support block 14. The external end of the passage 40 is connected to a vacuum source 46 and a supply source 48 of a liquid such as water through a conduit 44 having a suitable switching valve 42. On the other hand, in the circular protrusion 28 and the main portion 26 of the chuck table 5 are formed a plurality of pores (not shown) extending from the under surface of the circular protrusion 28 to the upper surface of the main portion 26. When a workpiece such as a semiconductor wafer is placed on the upper surface of the chuck table 6 in the workpiece unloading and loading station A, the switching valve 42 is operated to connect the passage 40 to the vacuum source 46. Then, air is sucked through the plurality of pores (not shown) formed in the chuck table 6, the space 34, the passage 36, the manifold 38, the passage 40 and the conduit 44 to thus hold the workpiece by suction onto the chuck table 6. When the workpiece is taken out from the chuck table 6 in the workpiece unloading and loading station A, the switching valve 42 is operated to connect the passage 40 to the supply source

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48. Then, a liquid such as water is supplied to the upper surface of the chuck table 6 through the conduit 44, the passage 40, the manifold 38, the passage 36, the space 34 and the plurality of pores (not shown) 5 formed in the chuck table 6 to thus float up the workpiece which has been held by suction to the chuck table 6.

In the illustrated surface grinding apparatus, a chuck table rotating means for rotating the 10 plurality of chuck tables 6 is also provided. With reference to Figure 2, a nearly disc-shaped central support block 50 is fixed to the central portion of the substantially horizontal upper surface of the support table 4. At the peripheral edge portion of 15 this central support block 50 is unitedly formed a cylindrical upright wall 52 extending upwardly, and onto this upright wall 52 is fixed a disc-shaped support plate 54. In the central portion of the upper surface of the central support block 50 is formed a 20 circular depression 56 and in the central portion of the support plate 54 is formed a circular through opening 58 extending vertically. Bearing members 60 and 62 are disposed in the depression 56 and the opening 58 respectively, and a central rotating shaft 25 64 upwardly extending substantially perpendicularly from the depression 56 is rotatably supported by these bearing members 60 and 62. In the upper surface of the central support block 50 are further formed four circular depressions 66 correspondingly positioned 30 to the angular positions of the chuck tables 6 respectively, and in the support plate 54 are formed four circular openings 68 coordinatively positioned with these four depressions 66 respectively. (Only one depression 66 and one opening 68 are shown in

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Figure 2.) Bearing members 70 and 72 are disposed in the depressions 66 and openings 68 respectively, and rotating shafts 74 upwardly extending substantially perpendicularly from the depressions 66 are rotatably supported by these bearing members 70 and 72. The upper end portion of the aforesaid central rotating shaft 64 extending upwardly beyond the support plate 54 is drivingly connected to a rotating source 76 such as an electric motor through a suitable transmitting element (not shown). The rotating source 76 may be mounted on the support table 4 through a suitable support frame (not shown) or may be mounted at a suitable position separate from the support table 4. A gear 78 is fixed to the central rotating shaft 64 at its middle portion between the central support block 50 and the support plate 54. On the other hand, gears 80 are fixed to the rotating shafts 74 respectively at their middle portions between the central support block 50 and the support plate 54, and each of these gears 80 is engaged with the gear 78. Toothed pulleys 82 are fixed to the rotating shafts 74 respectively at their upper end portions protruding upwardly beyond the support plate 54. Toothed pulleys 84 are also fixed to the rotating shafts 24 respectively to which the chuck tables 6 are fixed, and endless toothed belts 86 are wound around the corresponding toothed pulleys 82 and 84 respectively. Consequently, as is understood, when the common rotating source 76 is energized to rotate the central rotating shaft 64, for example, in the direction shown by an arrow 88 in Figure 1, each of the plurality of chuck tables 6 is caused to rotate in the direction shown by an arrow 90 in Figure 1 through common drive connecting means (i.e. the gear 78) and drive

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connecting means (i.e. the gear 80, the toothed pulley 82, the toothed belt 86 and the toothed pulley 84) provided with respect to each of the plurality of chuck tables 6.

5 In the illustrated embodiment, protect covers 92, 94 and 96 are also disposed on the support table 4 by suitable support means (not shown). These protect covers 92, 94 and 96 prevent a cooling liquid such as water used when grinding the workpiece held on the  
10 chuck table 6 with the grinding wheel 8 to be described hereinafter or produced grinding chips from coming into the above-described various rotation supporting constituents and drive connecting elements disposed on the support table 4.

15 In each of the grinding stations shown by letters B, C and D in Figure 1, a grinding wheel assembly is disposed adjacent to the support table 4. (Only the grinding wheels 8 in the grinding wheel assemblies are simply shown by two-dot chain line in  
20 Figure 1 for clearness of the drawing.) The structures of the grinding wheel assemblies disposed to the grinding stations B, C and D may be substantially the same and only one grinding wheel assembly is shown in Figure 2. With reference to Figure 2, the  
25 illustrated grinding wheel assembly shown generally by a numeral 98 has a static support base stand 100 positioned adjacent to the peripheral edge of the support table 4. A horizontally moving block 102 is mounted on the base stand 100 by suitable support  
30 means (not shown) for substantially horizontal movement in the right-and-left direction in Figure 2. Conveniently, the moving direction of the horizontally moving block 102 is substantially consistent with a radial direction of the support table 4. A first

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wheel moving means 104 including a driving source such as an electric motor exists between the base stand 100 and the horizontally moving block 102, and the horizontally moving block 102 is moved by this  
5 first wheel moving means 104. A perpendicularly moving block 106 is mounted on the horizontally moving block 102 by suitable support means (not shown) for substantially perpendicular movement in the up-and-down direction. A second wheel moving means 108  
10 including a driving source such as an electric motor exists between the horizontally moving block 102 and the perpendicularly moving block 106, and the perpendicularly moving block 106 is vertically moved by this second wheel moving means 108. A rotating  
15 shaft 110 is rotatably mounted on the perpendicularly moving block 106. A grinding wheel assemblage 112 which is conveniently a so-called cup-shaped grinding wheel assemblage is fixed to the lower end of the rotating shaft 110 protruding downwardly from the  
20 perpendicularly moving block 106. The illustrated grinding wheel assemblage 112 consists of a reversed-cup-shaped support member 114 fixed to the lower end of the rotating shaft 110 and the grinding wheel 8 fixed to an annular open end of the support member 114.  
25 The grinding wheel 8 is conveniently of an annular shape as a whole, but it is not limited to one continuously extending annularly as illustrated, and one which is made annular as a whole by fixing a plurality of arc-shaped pieces to the annular open end  
30 of the support member 114 at circumferentially spaced positions may also be conveniently used. The rotating shaft 110 is drivingly connected to a wheel rotating means 116 such as an electric motor mounted on the perpendicularly moving block 106, and the rotating

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shaft 110 and the grinding wheel assemblage 112 fixed thereto are rotated about the central axis 118 of the rotating shaft 110 by this wheel rotating means 116. The central axis 118 may extend substantially perpendicularly. If desired, the central axis 118 may be inclined in a predetermined direction, for example, in the right direction as one faces down in Figure 2 by a small angle (for example,  $0.004^{\circ}$  to  $0.01^{\circ}$ ). Conveniently, the grinding wheel 8 itself is one formed by bonding super abrasive grains such as natural or synthetic diamond grains or cubic boron nitride grains by a suitable method. Preferably, the grain size of the grinding wheel 8 used in the rough grinding station B is relatively large, the grain size of the grinding wheel 8 used in the intermediate grinding station C is intermediate and the grain size of the grinding wheel 8 used in the finishing grinding station D is relatively small.

In the next place, surface grinding manners of a semiconductor wafer by the above-described surface grinding apparatus are described.

In the first surface grinding manner, the support table 4 is intermittently rotated every  $90^{\circ}$  in the direction shown by the arrow 12 from the angular position illustrated in Figure 1. Consequently, each of the four chuck tables 6 mounted on the support table 4 is positioned to the workpiece unloading and loading station A, the rough grinding station B, the intermediate grinding station C and the finishing grinding station D successively. While the chuck table 6 is positioned to the workpiece unloading and loading station A, a semiconductor wafer W which has been ground on its surface is taken out of the chuck table 6 by the suitable unloading means (not shown)

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as described hereinbefore. Then, a new semiconductor wafer W to be ground on its surface is placed on the chuck table 6 by the suitable loading means (not shown) as illustrated by two-dot chain line in Figure 1 and Figure 2, and held by suction onto the chuck table 6 as described hereinbefore. In these unloading and loading of a semiconductor wafer W, it is necessary to stop the rotation of the chuck table 6 itself, and therefore, the rotation of the chuck tables 6 is not started for a predetermined time after the support table 4 is rotated by  $90^{\circ}$  and stopped at a specific angular position, and during this time the unloading and loading of a semiconductor wafer W is carried out in the workpiece unloading and loading station A. Subsequently, the rotation of the chuck tables 6 is started for the grinding in the grinding stations B, C and D.

The grinding in each of the grinding stations B, C and D may be carried out by the following procedure. Mainly with reference to Figure 1, when the rotation of the support table 4 is stopped to stop the support table 4 at the specific angular position, the grinding wheel 8 is situated over a semiconductor wafer W held on the chuck table 6 in each of the grinding stations B, C and D. As illustrated in Figure 1 and Figure 2, the relative position of the grinding wheel 8 to the semiconductor wafer W is preferably where the grinding edge of the grinding wheel 8 is caused to pass over the substantial center of the surface of the nearly disc-shaped semiconductor wafer W. (Generally, the semiconductor wafer W is substantially circular except for a straight-line periphery called an orientation flat.) In order to meet this requirement, in Figure 1 and Figure 2, the

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central axis 118 (Figure 2) of the grinding wheel 8 is shifted outwardly in a radial direction of the support table 4 with reference to the central axis (extending vertically to the paper in Figure 1 and  
5 extending in an up-and-down direction in Figure 2) of the semiconductor wafer W. If desired, however, it may be shifted in another direction, for example, in a circumferential direction of the support table 4 as illustrated in Figure 3. In order to grind the surface  
10 of the semiconductor wafer W, the chuck table 6 and the semiconductor wafer W held thereon are rotated in the direction shown by the arrow 90 (or in its reverse direction) at, for example, 1 to 100 r.p.m. by the chuck table rotating means 76 (Figure 2).  
15 Simultaneously, the grinding wheel 8 is rotated in the direction shown by an arrow 120 (or in its reverse direction) at a relatively high speed of, for example, 500 to 5000 r.p.m. by the wheel rotating means 116 (Figure 2). In addition, the perpendicularly moving  
20 block 106 is lowered at a relatively low speed of, for example, 0.001 to 1.0 mm/min. by the second wheel moving means 108 (Figure 2) to thus lower the grinding wheel 8 toward the semiconductor wafer W. As a result, the rotating grinding wheel 8 acts on the rotating  
25 semiconductor wafer W, whereby the surface of the semiconductor wafer W is ground with a gradually increased grinding depth. The grinding depth of the surface of the semiconductor wafer W is determined by the lowered amount of the grinding wheel 8. In this  
30 kind of surface grinding manner, if there is a small offset between the grinding edge of the grinding wheel 8 and the substantial center of the surface of the semiconductor wafer W, as is easily understood, a small unground projection remains in the central



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area of the surface of the semiconductor wafer W. In this case, after the grinding wheel 8 is lowered by a predetermined amount, the horizontally moving block 102 is reciprocated to some extent to reciprocate the grinding wheel 8 to some extent against the surface of the semiconductor wafer W, whereby the unground projection can be ground and disappear. When the surface of the semiconductor wafer W is ground as required, the grinding wheel 8 is raised, and the rotation of the grinding wheel 8 and the rotation of the chuck table 6 and the semiconductor wafer W held thereon are stopped. Subsequently, the support table 4 is rotated by 90°.

In place of the above-described first surface grinding manner, the following second surface grinding manner may be carried out. In this second surface grinding manner, in the beginning of the grinding, the grinding wheel 8 is situated outside the semiconductor wafer W held on the chuck table 6 as shown by a two-dot chain line 8A in Figure 4. The vertical position of the grinding wheel 8 is set up at a required grinding depth, namely, is set up so that the lower end of the grinding wheel 8 is below the surface of the semiconductor wafer W by the required grinding depth. In a similar way as in the first surface grinding manner, the chuck table 6 and the semiconductor wafer W held thereon are rotated in the direction shown by the arrow 90 (or in its reverse direction) at a relatively high speed and the grinding wheel 8 is rotated in the direction shown by the arrow 120 (or in its reverse direction) at a relatively high speed. Furthermore, the horizontally moving block 102 is moved in the left direction in Figure 4 at a relatively low speed of, for example, 100 to 500 mm/min.

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by the first wheel moving means 104 to thus move the grinding wheel 8 in the direction shown by an arrow 122 from the position shown by the two-dot chain line 8A to the position shown by a two-dot chain line 8B in Figure 4. The position of the grinding wheel 8 shown by the two-dot chain line 8B in Figure 4 may be the same with the position of the grinding wheel 8 shown by two-dot chain line in Figure 1. As a result, the rotating grinding wheel 8 successively acts on the semiconductor wafer W from its peripheral edge toward its center according to its movement in the direction shown by the arrow 122 to grind the surface of the semiconductor wafer W. The grinding depth of the surface of the semiconductor wafer W is defined by the initially established grinding depth of the grinding wheel 8.

In place of the above-described first and second surface grinding manners, the following third surface grinding manner may be carried out. Mainly with reference to Figure 1, while in the first and second surface grinding manners the support table 4 is stopped at the specific angular position during the grinding, in the third surface grinding manner the support table 4 is continuously rotated in the direction shown by the arrow 12 at a relatively low speed of, for example, 100 mm/min. to 500 mm/min. in the moving speed of the semiconductor wafer W held on the chuck table 6 in the direction shown by the arrow 12 to continuously move the semiconductor wafer W held on the chuck table 6 in the direction shown by the arrow 12 and to permit its passage beneath the grinding wheels 8 at least in the grinding stations B, C and D. On the other hand, the grinding wheel 8 is set up at a required grinding depth, namely, is set up so that

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the lower end of the grinding wheel 8 is below the surface of the semiconductor wafer W by the required grinding depth, at the position shown by two-dot chain line in Figure 3 (or at the position shown by two-dot chain line in Figure 1 or a position a little inside than that in the radial direction). Similarly as in the first and second surface grinding manners, the semiconductor wafer W held on the chuck table 6 is rotated in the direction shown by the arrow 90 (or in its reverse direction) at a relatively high speed and the grinding wheel 8 is rotated in the direction shown by the arrow 120 (or in its reverse direction) at a relatively high speed. As a result, when the semiconductor wafer W held on the chuck table 6 is permitted passage beneath the grinding wheel 8 by the continuous rotation of the support table 4, the rotating grinding wheel 8 acts on and grinds the surface of the rotating semiconductor wafer W. The grinding depth of the surface of the semiconductor wafer W is defined by the initially established grinding depth of the grinding wheel 8.

As is clear from the above description about the one embodiment of the surface grinding apparatus constructed in accordance with this invention, in the surface grinding apparatus constructed in accordance with this invention, the grinding wheel 8 is rotated and a workpiece such as a semiconductor wafer W is also rotated when grinding the surface of the workpiece. Therefore, although the grinding wheel 8 having a considerably larger outer diameter than the outer diameter of the workpiece is used in the illustrated embodiment, even if the outer diameter of the grinding wheel 8 is nearly the same with, or somewhat smaller than, the outer diameter of the

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workpiece, the whole surface of the workpiece can be uniformly ground. Then, for example, even if the semiconductor wafer W is made large in diameter, it is not always necessary to make the grinding wheel 8 large in diameter accordingly. Furthermore, since the relative movement of the workpiece and the grinding wheel 8 in the grinding is defined by at least both of the rotation of the grinding wheel 8 and the rotation of the workpiece, the grinding trails on the surface of the workpiece by the grinding wheel 8 extend in various directions throughout the whole surface of the workpiece and become very complicated. Therefore, the grinding resistance is relatively small and the fluctuations of the grinding resistance are sufficiently small. It is possible to carry out a sufficiently uniform grinding throughout the whole surface of the workpiece.

Figure 5 illustrates a modified embodiment of the chuck table rotating means. In this modified embodiment, a central support block 200 is fixed to the central portion of the substantially horizontal upper surface of the support table 4. This central support block 200 has a disc-shaped base portion 202 and a cylindrical support portion 204 upwardly extending substantially perpendicularly from the central portion of the upper surface of this base portion 202. On the other hand, at the lower portion of a central rotating shaft 206 is formed a large-diameter portion 208, and in this large-diameter portion 208 is formed a circular depression 210 open downwardly. The large-diameter portion 208 of the central rotating shaft 206 is rotatably mounted on the cylindrical support portion 204 of the central support block 200 through bearing members 212 and 214. Specifically,

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the under surface of the bearing member 212 is caused to abut against the upper surface of the base portion 202 of the central support block 200, an annular spacer member 216 is disposed between the bearing member 212 and the bearing member 214, the upper surface of the bearing member 214 is caused to abut against the bottom surface (upper surface) of the circular depression 210, and thus the bearing members 212 and 214 are held at required positions. The upper end portion of the central rotating shaft 206 is drivingly connected to the rotating source 76 such as an electric motor through a suitable transmitting element (not shown). An annular flange 218 is formed on the outer peripheral surface of the large-diameter portion 208 of the central rotating shaft 206 and a gear 220 is fixed onto this annular flange 218.

To the upper surface of the support table 4 are also fixed four support blocks 222 correspondingly positioned to the angular positions of the four workpiece holding chuck tables 6 respectively. (Only one support block 222 is illustrated in Figure 5.) Each of the support blocks 222 is provided with drive connecting elements including pneumatic clutches. Specifically, each of the support blocks 222 has a lower large-diameter cylindrical portion 224 and an upper small-diameter cylindrical portion 226. A nearly cylindrical rotating member 232 is rotatably mounted on the upper small-diameter cylindrical portion 226 through bearing members 228 and 230. Specifically, the under surface of the bearing member 228 is caused to abut against the upper surface of the large-diameter cylindrical portion 224, an annular spacer member 234 is disposed between the bearing member 228 and the bearing member 230, the upper

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surface of the bearing member 230 is caused to abut against the under surface of an annular flange 236 formed on the inner peripheral surface of the rotating member 232, and thus the bearing members 228 and 230 are held at required positions. An annular member 238 is fixed to the upper surface of the upper small-diameter cylindrical portion 226, and the annular flange 236 of the rotating member 232 is restrained by the under surface of this annular member 238 to prevent the rotating member 232 from moving upwardly. An annular flange 240 is formed on the outer peripheral surface of the rotating member 232 and a gear 242 is fixed onto this annular flange 240. This gear 242 is engaged with the aforesaid gear 220. To the upper end of the rotating member 232 is fixed an annular friction plate 244 made of a material having a high friction coefficient such as synthetic rubber. On the other hand, in the lower large-diameter cylindrical portion 224 of the support block 222 is formed a circular depression 246 open downwardly. The under surface of this circular depression 246 is closed by the support table 4 and the circular depression 246 works as a cylinder of a pneumatic mechanism as will be clear from a description hereinafter. A through hole 248 extending substantially perpendicularly is further formed in the support block 222 and a shaft 254 is slidably mounted in this through hole 248 for movement in the perpendicular direction. The shaft 254 extends upwardly beyond the upper surface of the upper small-diameter cylindrical portion 226 and a gear 262 is rotatably mounted on the upper end portion of the shaft 254 by a bearing member 258 and a stop ring 260 so that the gear 262 cannot move in the axial direction with respect to the shaft 254.

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On the under surface of the gear 262 is formed an annular projection 264 facing to the friction plate 244. To the lower end of the shaft 254 located in the circular depression 246 is fixed a disc 266 which works  
5 as a piston of a pneumatic cylinder mechanism. A spring means 268 such as a plurality of flat springs is disposed between the upper surface of the support table 4 and the disc 266, and this spring means 268 springly biases upwardly the disc 266, accordingly  
10 the shaft 254 and the gear 262 mounted thereon. On the other hand, in the lower large-diameter cylindrical portion 224 of the support block 222 is formed a passage 270 extending from its internal end open to the upper end of the circular depression 246 to its external  
15 end open to the outer peripheral surface of the lower large-diameter cylindrical portion 224. The external end of the passage 270 is adapted for selective communication with a compressed air supply source 276 or the atmosphere through a conduit 274 having a  
20 suitable switching valve 272. Upon communication of the passage 270 with the compressed air supply source 276, the disc 266 is lowered to the illustrated position against the springy biasing action of the spring means 268 by compressed air supplied to the circular  
25 depression 246. Therefore, the shaft 254 and the gear 262 are lowered to the connection position shown by real line. In this connection position, the annular projection 264 formed on the under surface of the gear 262 is pressed against the friction plate 244 to thus  
30 frictionally connect the gear 262 to the rotating member 232. On the other hand, upon communication of the passage 270 with the atmosphere, the disc 266 is raised by the springy biasing action of the spring means 268. Therefore, the shaft 254 and the gear 262

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are raised to the release position shown by two-dot chain line. In this release position, the annular projection 264 formed on the under surface of the gear 262 is kept apart upwardly from the friction plate 244 to thus release the connection of the gear 262 with the rotating member 232. Furthermore, a gear 278 is fixed to the rotating shaft 24 to which the chuck table 6 is fixed, and this gear 278 is engaged with the gear 262. Since the structure in the modified embodiment illustrated in Figure 5 such as the mounting manner of the chuck table 6 is substantially the same with that in the embodiment illustrated in Figure 2 except for the above-described structure, its description is omitted in this specification.

In the modified embodiment illustrated in Figure 5, the drive connecting means disposed between the common driving source 76 and each of the plurality of (four) chuck tables 6 includes a clutch means (i.e. the friction plate 244 fixed to the rotating member 232, the annular projection 264 formed on the gear 262 and the like). As a result, the rotation of each of the plurality of chuck tables 6 can be independently controlled. Specifically, when the gear 262 is lowered to the connection position shown by real line, the rotation of the driving source 76 is transmitted to the chuck table 6 through the central rotating shaft 206, the gear 220, the gear 242, the rotating member 232, the friction plate 244, the gear 262 and the gear 278 to thus rotate the chuck table 6. When the gear 262 is raised to the release position shown by two-dot chain line, the connection between the friction plate 244 and the gear 262 is released, and thus the rotation of the chuck table 6 is stopped. If desired, in order to immediately stop the rotation of



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the chuck table 6 when the gear 262 is raised to the release position shown by two-dot chain line, a brake means (not shown) which works on the chuck table 6 synchronously with the raise of the gear 262 may also  
5 be provided. In the modified embodiment illustrated in Figure 5, since the rotation of each of the plurality of chuck tables 6 can be independently controlled, for example, the grinding operations can be carried out in the grinding stations B, C and D (Figure 1)  
10 respectively while rotating three chuck tables 6 existing in the grinding stations B, C and D respectively, while the workpiece unloading and loading operations can be carried out in the workpiece unloading and loading station A (Figure 1) while  
15 stopping the chuck table 6 existing in the workpiece unloading and loading station A, and thus the operation efficiency can be improved. If desired, a position detector (not shown) may be additionally provided to each of the chuck tables 6 to automatically control the  
20 connection and release of the clutch means, to rotate the chuck tables 6 while each of the chuck tables 6 exists at least in the grinding stations B, C and D and to stop the chuck tables 6 while each of the chuck tables 6 exists at least in the workpiece unloading  
25 and loading station A.

While this invention has been described in detail hereinabove with reference to the accompanying drawings showing specific embodiments of the surface grinding apparatus constructed in accordance with this  
30 invention, it should be understood that this invention is not limited to these specific embodiments, and various changes and modifications are possible without departing from the scope of this invention.

WHAT IS CLAIMED IS:

1. A surface grinding apparatus comprising a support stand (4), at least one workpiece holding chuck table (6) rotatably mounted on the support stand (4), a rotatably mounted grinding wheel (8) for grinding the surface of a workpiece (W) held on the chuck table (6), chuck table rotating means (76) for rotating the chuck table (6) and wheel rotating means (116) for rotating the grinding wheel (8), wherein when grinding the surface of the workpiece (W) held on the chuck table (6) with the grinding wheel (8), the grinding wheel (8) is rotated and the chuck table (6) is also rotated to rotate the workpiece (W) held on the chuck table (6).
2. A surface grinding apparatus according to claim 1 wherein the grinding wheel (8) is of an annular shape as a whole and the central axis (118) of rotation of the grinding wheel (8) is disposed generally parallel to the central axis of rotation of the chuck table (6).
3. A surface grinding apparatus according to claim 1 wherein the support stand comprises a rotatably mounted support table (4), and table rotating means (76) is provided for rotating the support table (4).
4. A surface grinding apparatus according to claim 3 wherein the grinding wheel (8) is mounted for movement in the direction of its central axis (118) of rotation, wheel moving means (108) is provided for moving the grinding wheel (8) in the direction of its central axis (118) of rotation, and when grinding the surface of the workpiece (W) held on the chuck table (6) with the grinding wheel (8), the support table (4) is stopped at a

predetermined angular position so that the workpiece (W) held on the chuck table (6) has a predetermined relationship with the grinding wheel (8), and the grinding wheel (8) is moved toward the chuck table (6) by the wheel moving means (108) to thus gradually increase the grinding depth of the surface of the workpiece (W).

5. A surface grinding apparatus according to claim 4 wherein the workpiece is nearly disc-shaped, and when the support table (4) is stopped at the predetermined angular position, the workpiece (W) is positioned with respect to the grinding wheel (8) so that the outer peripheral edge of the grinding wheel (8) passes through the substantial center of the workpiece (W).

6. A surface grinding apparatus according to claim 3 wherein when grinding the surface of the workpiece (W) held on the chuck table (6) with the grinding wheel (8), the support table (4) is continuously rotated by the table rotating means (76) to permit passage of the workpiece (W) held on the chuck table (6) beneath the grinding wheel (8).

7. A surface grinding apparatus according to claim 3 wherein the grinding wheel (8) is mounted for movement in a direction generally perpendicular to its central axis (118) of rotation, wheel moving means (104) is provided for moving the grinding wheel (8) in the direction generally perpendicular to its central axis (118) of rotation, and when grinding the surface of the workpiece (W) held on the chuck table (6) with the grinding wheel (8), the support table (4) is stopped at a predetermined angular position and the grinding wheel (8) is moved from the peripheral edge toward the center of the workpiece (W)

held on the chuck table (6) by the wheel moving means (104) to thus gradually grind the surface of the workpiece (W) from its peripheral edge toward its center.

8. A surface grinding apparatus according to claim 7 wherein the workpiece (W) is nearly disc-shaped and the grinding wheel (8) is moved by the wheel moving means (104) up to the position where its outer peripheral edge passes through the substantial center of the surface of the workpiece (W).

9. A surface grinding apparatus according to claim 3 wherein the support table (4) is provided with a plurality of workpiece holding chuck tables (6) at circumferentially spaced positions and the chuck table rotating means (76) includes one common driving source and a plurality of drive connecting means disposed between the common driving source and each of the plurality of chuck tables (6) respectively.

10. A surface grinding apparatus according to claim 9 wherein each of the plurality of drive connecting means has clutch means for controlling connection and release.

11. A surface grinding apparatus according to claim 10 wherein the clutch means is a pneumatic clutch controlled by pressurized air.

12. A surface grinding apparatus according to claim 10 wherein one workpiece unloading and loading station (A) and a plurality of grinding stations (B, C, D) are defined at circumferentially spaced positions of the support table (4) and a grinding wheel (8) is provided in each of the plurality of grinding stations (B, C, D).

13. A surface grinding apparatus according to claim 12 wherein while each of the plurality of chuck tables (6) exists at least in either of the plurality of grinding stations (B, C, D), the clutch means is connected and each of the plurality of chuck tables (6) is rotated, whereas while each of the plurality of chuck tables (6) exists at least in the workpiece unloading and loading station (A), the clutch means is released and the rotation of each of the plurality of chuck tables (6) is stopped.

14. A surface grinding apparatus according to claim 13 wherein the support table (4) is continuously rotated by the table rotating means (76), whereby each of the plurality of chuck tables (6) is continuously moved through the workpiece unloading and loading station (A) and the plurality of grinding stations (B, C, D).

15. A surface grinding apparatus according to claim 1 wherein the workpiece (W) is a semiconductor wafer.

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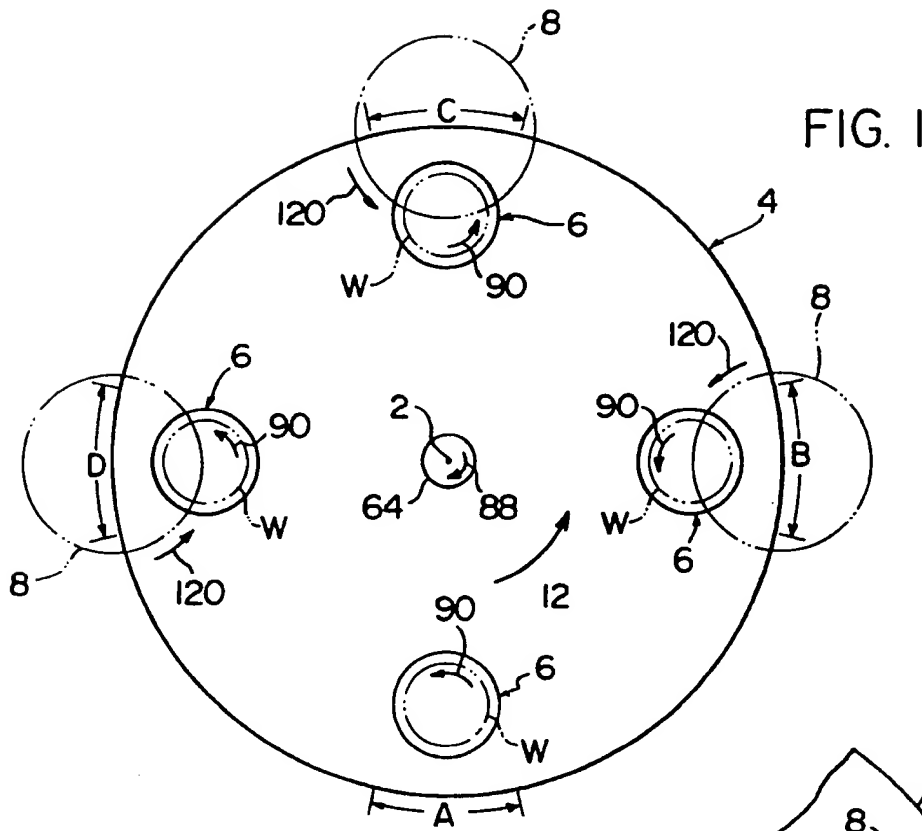


FIG. 3

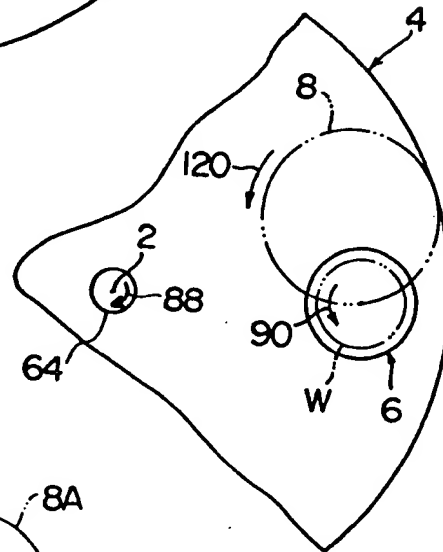


FIG. 4

